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Manning Diversified Forest Products
Research Trust Fund
MDFP 8/96
Impacts of Logging on Boreal Birds In
The Mixedwood Forest
Final Report 1998

Alberta
ENVIRONMENTAL PROTECTION

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The Mixedwood Forest
Final Report 1998

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By Dr. Susan Hannon
Professor Department of Biological Sciences
University of Alberta
Edmonton, Alberta
Canada

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DISCLAIMER

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Abstract:

The main goals of this research were to document the species composition of raptors in intact and logged boreal mixedwood fores and to determine habitat associations of forest raptors, particularly the Barred Owl which may be sensitive to logging. Using a variety of census techniques we documented the presence of 16 species of forest raptors at our Calling Lake study area. Of these, the red-tailed hawk and American kestrel were detected at a higher rate in fragmented forest and there was a trend for an increase in Great-horned owls and a slight decrease in Barred Owls as the study area became increasingly fragmented. Censuses of these two owl species over a larger spatial scale ($900km^2$) indicated that great-horned owls occurred in most habitats sampled, but Barred Owls were not found in old forest next to burns. Barred Owls did occur along transects where old forest was interspersed with clearcuts and young forest, but spatial overlap between Great Horned Owls and Barred Owls was highest in areas with clearcuts. Our radio-tracking data on Barred Owls indicates that predation by Great Horned Owls is a significant mortality factor, and thus Barred Owls may not fare well in habitats where clearcuts are interspersed through old forest. Further analysis of these data using GIS is ongoing to determine habitat associations at this larger scale (i.e. is there a threshold amount of clearcutting along a transect, above which Barred Owls are not detected?). We used detailed radio-tracking data on nine Barred Owls to quantify habitat selection at the nest and territory levels. Barred Owls nested primarily in large (>34cm dbh) *Populus* snags surrounded by high numbers of large snags and with a tall shrub understory, features of old growth stands. Their territories included slightly more old and mature forest and less young forest than the landscape in the study area at large.

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Introduction:

Alberta's boreal mixedwood forest is being rapidly fragmented and habitats are being lost due to agricultural activities, logging, mining and oil and gas exploration and development. Under the operating ground rules for the forest industry in Alberta, aspen-dominated stands will be harvested following a two- or three-pass clearcutting system with a projected rotation period of about 70 years (Alberta Energy/Forestry, Lands and Wildlife 1992). This will result in a rapid fragmentation of aspen-dominated stands, and a truncation of the current age distribution. Stands older than rotation age will only be found in riparian buffer strips along permanent watercourses, or as stands that are too small or isolated to be of commercial value (Schmiegelow and Hannon 1993). Under this harvesting regime, wildlife that benefits from the creation of edge and that does not need large areas of continuous forest will be favoured. It will be detrimental to species susceptible to negative edge effects (such as increased predation), those that require large undisturbed areas (area-sensitive species), and those that are dependent on old aspen forest. Some species of raptors (hawks, owls) may suffer in fragmented landscapes because of their large home range requirements. For example, Carey et al. (1992) found that northern spotted owls (Strix occidentalis caurina) living in fragmented landscapes had larger territories and lower foraging efficiency than those in continuous woodlands.

The Barred Owl *(Strix varia)* is considered to be a species of management concern in Alberta (Alberta Environmental Protection 1996). Its association with old growth forest and preference for large diameter cavity trees for nesting and roosting in other parts of its range (Takats 1997, Mazur et al. 1997) and its low population densities and large home ranges (Bosakowski et al. 1987) may make it susceptible to loss and fragmentation of old growth forest. At the stand level, loss of older forest may result in loss of nesting and roosting structures and at larger scales, when forest is fragmented owls may need to increase their home ranges to compensate for habitat loss and may be susceptible to increased predation by the invading Great Horned Owl *(Bubo virginianus)* (Laidig and Dobkin 1995). Thus, studies on the impacts of forestry on owls must be done at several spatial scales and with radio-marked birds. There have been no studies on this species in the boreal mixedwood forest of Alberta.

Project Objectives:

As part of a larger study on the effects of forest fragmentation and habitat loss on birds in the boreal forest, Hannon and Gordon Court initiated a study of forest raptors in 1994. Funding from Manning Diversified allowed Msc student Ben Olsen to continue these studies. Since Ben has also analysed some of the data collected earlier by Court, we have included these data in the report for completeness. At the time we began our raptor studies, little was known about the species composition, abundance, distrubution or habitat associations of boreal forest raptors. Thus, our first goal was to document which species were present in intact boreal mixedwood forest. Second, we wished to monitor changes in the raptor community as the study area was logged. Third, we chose the Barred Owl as our focal species (for reasons outlined above). We wished to document its habitat selection for nesting and for its territory and to determine its distribution (and that of the Great-horned Owl) in logged, unlogged and burned landscapes. Our final goal was to use the results to help the forestry industry to plan logging designs so that they will minimize impacts on sensitive forest birds.

Methods:

Study area

Studies on raptor community composition and radio-tracking of Barred Owls were done over 9 townships west and south of Calling Lake, Alberta. This area is dominated by old (80-130yr) aspen-dominated mixedwood forest and harvesting began in the area over the winters of 1994 and 1995. At a larger scale we surveyed Barred Owls and Great Horned Owls in four regions of north-central Alberta (900 km^2). Areas near Calling Lake, North Wabasca Lake, Owl River and Goodwin Lake were chosen because they are characteristic of the boreal mixedwood ecoregion (Strong and Leggat 1992) and contained logged, burned and intact forests. North Wabasca Lake has large unfragmented aspen stands; regenerating conifer clearcuts are the only harvested areas. Aspen stands at Owl River were initially logged in 1993 and Aspen stands at Goodwin Lake were fragmented by forest fire in 1992.

Raptor Community Composition Surveys at Calling Lake

Owls were suveyed from January to the end of April along a 100km transect at the Calling Lake study site. Fifty survey posts were spaced 2 km apart along these transects which pass through all representative habitat types in the area. We surveyed owls using a playback of taped territorial calls for each species. At each survey post, we called for owls on at least three separate occasions during the peak calling period for each species. Once owls were detected, we located their calling positions to stand type by triangulating on their position and marking these on maps. Dominant vegetation and age of stands from which owls were calling were determined from aerial photos, Phase III Forest Inventory or AVI maps of the region.

A measure of diurnal raptor species composition in the study area was obtained by surveys performed along forest transects of 54km each day from mid-May (post-migration) to mid-August (pre-migration). The transects were on forest cutlines or roads running through both uncut and fragmented (clear cut and partially cut) forest. Each survey was performed between 0600 and 1400hr, travelling by all-terrain vehicle driven at speeds averaging between 15 and 25 kilometers per hour. All raptors flushed from roadside trees or flying over cutlines/roadways were identified and the type of habitat was recorded for each observation. In order to gain presence/absence data for more secretive species (*e.g.*: accipitrine hawks), we used trapping grids for raptors along the transect route, spacing traps equally in both control and experimental forests. Twenty baited drop-lid and 5 drop-end raptor traps (after Kenward et al. 1983) were used during survey/trapping periods.

Larger scale Barred and Great Horned Owl surveys

Winter/spring surveys were done from February to the end of April. The sample unit was a 6 km transect consisting of 3 owl calling stations at 2 km intervals. Sampling stations along each transect were 2 km apart in order to ensure that owl responses from adjacent points represent different territories or different owls from the same territory (Bosakowski et al. 1987). Transects were separated by at least 5 km in order to maintain independence between the sample units. Five km is a conservative estimate of the home range diameter of a Barred Owl based on radio-telemetry data from Calling Lake (Gordon Court unpublished data, Olsen unpublished data). Transects were located through an equal proportion of fragmented (by harvesting or fire) and contiguous forest. Each of the owl calling stations were surveyed once in the early breeding season (February - March) and once late in the breeding season (March and April) in order to sample the peak calling times for most owl species. Call surveys began one hour after sunset on evenings when the temperature was above -25 C.

The procedure at each call station was as follows: (1) two minutes of pre-broadcast listening for unsolicited owl vocalizations, (2) eight minutes of broadcasting Boreal Owl (*Aegolius funereus*) calls, (3) two minutes of listening, (4) eight minutes of broadcasting Barred Owl calls, and (5) five minutes post-broadcast observation. Calls were broadcast in the four cardinal directions. The location of each owl response was determined by recording the direction of the call using a compass and estimating the distance within 1 km. We believe that a maximum sampling distance of 1 kilometer was a conservative estimate for our particular study area.

Methods for capturing and radio-tagging Barred Owls

Barred Owl territories at Calling Lake were located during the call surveys,and then individual owls were captured by attracting them with playbacks of Barred Owl territorial call to mist nests that had a live Barred Owl decoy in the centre. Three Barred Owls were captured using Swedish-Goshawk traps. We banded, radio-tagged and measured each bird. A harness constructed of Teflon strapping held the radio-transmitter on the back of the owl between the scapula (Gutterman *et al.* 1991). We measured wing chord (mm), foot pad (0.1 mm), body mass (g), tail length (mm) and primary molting pattern. Sex was determined by body mass (females larger than males) and by the presence of a brood patch (females).

Radio-telemetry surveillance to determine Barred Owl home range size, habitat use and mortality

Radio-tracking of Barred Owls was accomplished by triangulation or walking in on the birds. To triangulate we took three compass bearings from different locations where the radiotransmitter signal was loudest. Compass bearings were plotted in the field on photocopies of 1:20000 aerial photographs. We walked in on owls to find day roosts and nest sites. Home range estimates were calculated using the minimum convex polygon method

Habitat analysis of radio-telemetry locations and call survey points

Habitat analysis was conducted at three scales. First we measured vegetation structure and composition around nest and roost trees (n=10) and random points (n=30) within the owl's territories. At each cavity tree, we measured vegetation in 4 0.04ha plots, one centred on the cavity tree and the 3 others 40m away at 120, 240 and 360°. We tallied trees and snags by species and diameter class and calculated basal area. For the cavity tree and a random central tree we measured dbh, height, cavity height, cavity aspect and percent lean. Shrubs were sampled in a 0.008 ha nested subplot and we recorded species, numbers of saplings (<2.5cm) and poles (2.5-8cm). Canopy cover was estimated using a spherical densiometer. Mann Whitney U-tests and stepwise logistic regression were used to compare owl cavities to random sites.

Second we examined habitat use at the scale of the home range using compositional analysis. The study area was classified into 10 habitat classes using digital AVI maps and Arc/Info GIS. The classifications were YOUNG (young forest), TRBOG (treed bog, >70% black spruce), CUT (harvested), OLDMIX (old mixedwood), OLD DECID(old aspen), OLDCON (old conifer), MATMIX (mature mixedwood), MATDEC (mature deciduous), MATCON (mature coniferous), and OTHER (marsh, water, burn, roads). Stand origins for age classification were: OLD- older than 1890, MAT- 1891-1931, YOUNG- > 1931. Composition of home ranges were compared to composition of the landscape in the study area overall to determine if habitat selection by the owls was occurring.

Finally, we examined our large scale survey data of Barred and Great-horned Owls and using AVI inventory classified habitat associations along the transects where each owl species was found or not found. Digital inventory for the whole study area has only recently been received, so more detailed habitat analysis along these transects awaits GIS analysis.

Results and Discussion:

Raptor community composition at Calling Lake

Combining all three survey methods (diurnal transects, Swedish goshawk traps and nocturnal surveys for owl) we recorded a total of 16 species of raptors at Calling Lake (Table 1). Of these, the diurnal transect data indicated that the Red-tailed Hawk and American Kestrel sightings were 5 and 12 times higher respectively in the fragmented than the unfragmented portions of the transect. Both of these species were observed using clearcuts and are well known to be open-country species.

Table 1. Raptor species recorded at Calling Lake, Alberta

Red-tailed Hawk, *Buteo jamaicensis*	Osprey, *Pandion haliaetus*
American Kestrel, *Falco sparverius*	Merlin, *Falco columbarius*
Cooper's Hawk, *Accipiter cooperii*	Rough-legged Hawk, *Buteo lagopus*
Bald Eagle, *Haliaetus leucocephalus*	Barred Owl, *Strix varia*
Northern Harrier, *Circus cyaneus*	Northern Saw-whet Owl, *Aegolius acadicus*
Sharp-shinned Hawk, *Accipiter striatus*	Great Horned Owl, *Bubo virginianus*
Northern Goshawk, *Accipiter gentilis*	Northern Pygmy Owl, *Glaucidium gnoma*
Broad-winged Hawk, *Buteo playpterus*	Boreal Owl, *Aegolius funereus*

Winter owls were surveyed in 1994, 1995 and 1996 (Fig. 1) and fragmentation by logging increased over this period. Response frequencies over years did not vary significantly for any species except for the Boreal Owl (BOOW) which was significantly higher in 1995. The Boreal Owl is an irruptive species and follows cycles in its main prey base, small voles and mice. Thus, this change is not likely to be related to fragmentation. There was a trend for Great Horned Owl (GHOW) to increase and Barred Owl (BAOW) to decrease slightly over the 3 years. Northern Saw-whet Owls (NSWO) did not respond at a high rate. Given these results, we decided to survey only for Barred Owls and Great Horned Owls at larger spatial scales to look at the influence of forest age and whether the habitat was logged or burned. Survey points were located in old mixedwood forest next to recent clearcuts (<4yr), next to young forest (<40yr) and next to recent burn (<5yr). We are currently classifying the AVI inventory for the larger scale study area so cannot report here on exact habitat associations, but preliminary analysis indicates that Great Horned Owls were distributed at all sites (responded at 36% of stations in old uncut forest, 62% of stations in old forest next to recent clearcut, 43% of stations next to young forest and 45% of stations next to burns). Barred Owls had a more restricted distribution (36% in uncut, 50% next to clearcuts, 29% next to young forest and 0% next to burn). This indicates that Barred Owls can use habitats in which some clearcuts and young forest exist. More analysis is required on the AVI data to determine how much clearcut or young forest can be tolerated in Barred Owl territories (i.e. is there a threshold amount of clearcutting along a transect, above which Barred Owls are not detected?). The highest level of spatial overlap between the territories of the two species occurred in old forest next to clearcut. Given that Great Horned Owls can kill Barred Owls, the presence of Barred Owls in the uncut/cut landscapes may not be sustainable (see radiotagging results below).

Barred Owl density and home range size

In the breeding season of 1997, the density of Barred Owls was 0.04 pairs/km2, unchanged from 1996.

The density of Barred Owls in the Calling Lake study area is considerably lower than in other parts of its North American range where values of 0.147 pairs/km2 (Smith 1978), 0.157 pairs/km2 (Bosakowski *et al.* 1989) and 0.355 pairs/km2 (Elody 1983) have been reported. The density of Barred Owls at Calling Lake is similar to the density of this species in other regions of Alberta (Lisa Takats, unpublished data).

Over the period of this study 20 Barred Owls were radiotagged: 7 males, 8 females and 5 juveniles (Table 2). Four birds were killed by Great Horned Owls, indicating that this species can cause significant mortality where the two species overlap. We had sufficient data to calculate home range size for 9 adults: this ranged from 131.1 to 596.2 ha. Mean home range size of males (365.26 ± 153.68SE ha) did not differ from female (303.78 ± 167.57SE) home range size (Mann Whitney $U = 6.0$, $p = 0.327$). We use habitat composition of the home ranges to determine habitat associations (see below). We had insufficient data to compare home range size between fragmented and continuous areas. The five juveniles came from 3 different broods and although we had insufficient data to calculate home range sizes for them, we did note that they stayed close by the nest site in old forest for 4 months post-fledging and were attended by the parents. This indicates the potential importance of old growth forest for the young prior to independence from the parents.

Table 2. Record of radio-collared Barred Owls in this study.

Owl-ID[a]	Sex[b]	Location	Status	Date Captured	Method[c]	# relocations
#9501	M	BOG ROAD		14-4-95	MN	30
#9402	F	GROUSE ROAD	depredated	17-6-94	DL	23
#9503	F	TOWER ROAD		12-6-95	DL	28
#9504	F	GROUSE ROAD	depredated	20-4-95	HN	
#9605	F	QUINN CREEK		10-2-96	HN	31
#9606	M	WEST ROAD		12-5-96	DL	12
#9607	M	LONG LAKE		16-5-96	MN	27
#9608	F	SOUTH CAMP	depredated	28-5-96	MN	7
#9609	M	WOLF ROAD	depredated	28-6-96	MN	24
#9610	M	TOWER ROAD		3-7-96	DL	29
#9611	M	PARK		8-8-96	MN	17
#9712	M	HUSKY ROAD		3-4-97	MN	11
#9713	F	1000 ROAD		14-4-97	MN	10
#9714	F	TAWATINA		13-5-97	HN	
#9715	F	PELICAN CRK		5-6-97	MN	23
#9716	J	TAWATINA		27-5-97		6
#9717	J	TAWATINA		27-5-97		6
#9718	J	1000 ROAD		12-6-97		10
#9719	J	1000 ROAD		12-6-97		10
#9720	J	LAC LA BICHE		13-6-97		12

[a] first two digits in the owl-id correspond to the year that the bird was captured
[b] (M)ale, (F)emale and (J)uvenile
[c] Mist net (MN), modified Swedish goshawk drop trap (DL), hand net (HN)

<u>Microhabitat analysis of Barred Owl cavity trees</u>

Microhabitat characteristics around Barred Owl cavities were compared with randomly chosen potential cavities within the territory. Owl cavities had a larger diameter at breast height (dbh) than the reference cavities (Table 3). Cavity orientation also differed between occupied and unoccupied potential nest trees. Owl cavities had a northwest exposure while reference cavities had a northeastern exposure. Few of the other variables were significant in distinguishing owl cavity trees from random ones. In addition, all of the owls except one used >34cm dbh trembling aspen and balsam poplar snags for nesting. The exception

nested in a stick nest. In west central Alberta, all Barred Owls (n=6) nested in poplar tree cavities (Takats 1997). Thus, to provide suitable nest trees large diameter poplar or aspen trees and snags must be conserved.

Table 3. Means and standard errors of vegetation descriptors at Barred Owl cavities and reference cavities.

	Presence	Absence	*U* statistic	Significance
Cavity Tree Characteristics				
Cavity tree dbh (m)	51.6 (4.3)	42.1 (1.3)	86.5	0.046
Cavity height (m)	10.4 (2.1)	8.9 (0.9)	115.0	0.678
Cavity tree height (m)	16.0 (2.6)	10.8 (1.3)	90.5	0.062
Cavity orientation (degrees)	203.7 (41.9)	45.7 (29.8)	1.0	0.048
Cavity tree lean (%)	3.8 (2.0)	4.1 (1.9)	124.5	0.432
Overstory-Floristic*				
Deciduous basal area (m^2/ha)	22.8 (2.5)	19.2 (2.0)	111.0	0.233
Coniferous basal area (m^2/ha)	6.5 (3.0)	10.8 (2.1)	129.5	0.528
Small *Populus* stems/ha	216.3 (69.2)	281.5 (48.4)	122.0	0.396
Large *Populus* stems/ha	181.4 (27.0)	148.1 (19.0)	111.0	0.233
Small *Picea gluaca* stems/ha	66.7 (33.5)	138.4 (31.6)	113.0	0.259
Large *Picea gluaca* stems/ha	45.5 (24.9)	73.4 (16.0)	145.5	0.890
Small *Abies balsamea* stems/ha	26.2 (16.8)	63.2 (27.8)	146.0	0.914
Large *Abies balsamea* stems/ha	7.5 (5.3)	2.3 (1.1)	140.5	0.770
Physical Strata-understory				
Shrub density (10^3 stems/ha)	3.9 (0.7)	3.6 (0.4)	136.5	0.678
Saplings (10^3 stems/ha)	3.0 (0.7)	2.8 (0.3)	148.0	0.963
Poles (10^3 stems/ha)	0.9 (0.2)	0.8 (0.2)	126.0	0.469
Shrub height (m)	4.4 (1.02)	2.5 (0.6)	95.5	0.089
Coarse woody debris (m^3/ha)	22.4 (6.2)	18.6 (2.7)	134.0	0.634
Physical Strata-overstory**				
Canopy cover (%)	68.4 (4.7)	65.2 (3.4)	138.0	0.837
Canopy height (m)	24.9 (0.9)	24.6 (0.9)	136.0	0.678
Sub-canopy height (m)	8.5 (2.6)	9.1 (1.5)	142.0	0.818
Snag basal area (m^2/ha)	7.0 (1.2)	4.7 (0.4)	98.0	0.109
Large snags (no./ha)	25.6 (6.1)	9.6 (2.0)	68.5	0.009
Small snags (no./ha)	72.9 (20.7)	97.4 (11.0)	106.0	0.177

* Small stems are less than or equal to 23cm dbh. Large stems are greater than 23cm dbh
** Small snags are less than or equal to 34cm dbh. Large snags are greater than 34cm dbh.
P values are exact significance (1-tailed x 2), not corrected for ties.

Only two vegetation descriptors in the area around the cavity tree proved to be important predictors of cavity occupancy by Barred Owls (Table 4). Areas with a high number of large (>34 cm dbh) snags and a tall understory component (shrub height) were the only variables that discriminated owl cavities from random cavities within the territory. This model accurately classified 90% of all reference cavities and 40% of the owl cavities (overall model accuracy = 77.5%). The fit of the data to the logistic model was strong according to the Hosmer-Lemeshow chi-square test ($\chi^2 = 4.9930$, 7 df, p = 0.6608) and the log likelihood

ratio ($\chi^2 = 12.127$, 2 df, $p = 0.0023$). This means that owls are choosing large diameter snags for nesting and are searching for these in areas with a large number of large diameter snags in the vicinity and with high shrub height: both characteristics of old forest.

Table 4. Variables that entered and did not enter the stepwise logistic regression explaining owl presence/absence in cavity trees and surroundings.

(a) Vegetation descriptors entered into the multivariate analysis

Variable	**B**	**S.E.**	**Wald χ^2**	**Significance (p)**	**R**
Shrub height (m)	0.2583	0.1392	3.4446	0.0635	0.1792
Large snags (no./ha)	0.0823	0.0309	7.0869	0.0078	0.3363
constant	-3.4054	1.0307	10.9151	0.0010	

(b) Vegetation descriptors removed from the multivariate analysis

Variable	**Score**	**Significance (p)**
Cavity tree dbh (m)	1.1441	0.2848
Coarse woody debris (m^3/ha)	0.1456	0.7028
Large *Abies balsamea* (stems/ha)	0.8894	0.3456
Large *Picea gluaca* (stems/ha)	0.0151	0.9023
Large *Populus* (stems/ha)	1.1392	0.2858
Snag basal area (m^2/ha)	0.18	0.8585

Comparison of composition of home ranges vs landscape

The total area of each habitat type within summer home ranges was determined for each individual owl and these were then compared to the composition of the landscape in the study area (Fig. 2). Proportions were then normalized using the log ratio transformation and log ratio difference scores were computed. Habitat selection differed from random ($\chi^2 = 15.507$, 8 degrees of freedom, $p < 0.005$) (Fig 3) indicating that some selection of habitat was occurring. Overall, owl territories were more likely to be in old and mature forest than was represented in the landscape in general and less likely to be found in young forest (Fig 3). There was a fair amount of variability in the composition of the owl home ranges (Fig 3), particularly one female owl (#13) which included a high amount of young forest in its territory. No nest was found for this female, so she may have been a non-breeder. This suggests that young regrowing forests may not be suitable habitat for Barred Owl and that suitable amounts of mature and older forest must be provided to maintain this species on the landscape.

Management Implications:

1. Old forest (>100yr) with groupings of large diameter (>34cm dbh) *Populus* snags for nesting and roosting must be maintained to conserve Barred Owls.
2. Since Barred Owl home ranges are up to 600 ha in size, and since this species selects for forest types older than 1931 origin, large (>600ha) contiguous patches of old and mature forest should be maintained on the landscape. This area may be revised upwards, once we analyse winter home range size. Fragmentation by clearcutting may increase mortality of Barred Owls through predation by Great Horned Owls, so these large patches should not be harvested.
3. Given its prediliction for old and mature forest, the Barred Owl would be a good indicator species for integrity of old boreal mixedwood forest. It is easily censused in late winter using call playbacks. Protecting habitat for the Barred Owl will result in protection of many other old growth species.
4. To maintain Barred Owls in a managed landscape, a system of "floating" reserves may have to be implemented where large blocks (>600ha) may be harvested and then reharvested on an extended rotation period (>120yr). At any point in time over the larger landscape, there should be several large blocks of old forest. Leaving patches of residual trees of 1ha or larger within cutblocks will provide old snags for nesting and roosting habitat in the future.
5. Management for Barred Owls cannot be done in isolation and must be done in the context of other potentially sensitive species in the boreal forest.
6. These recommendations should remain preliminary until all data analysis is complete on this project (projected Jan. 1999).

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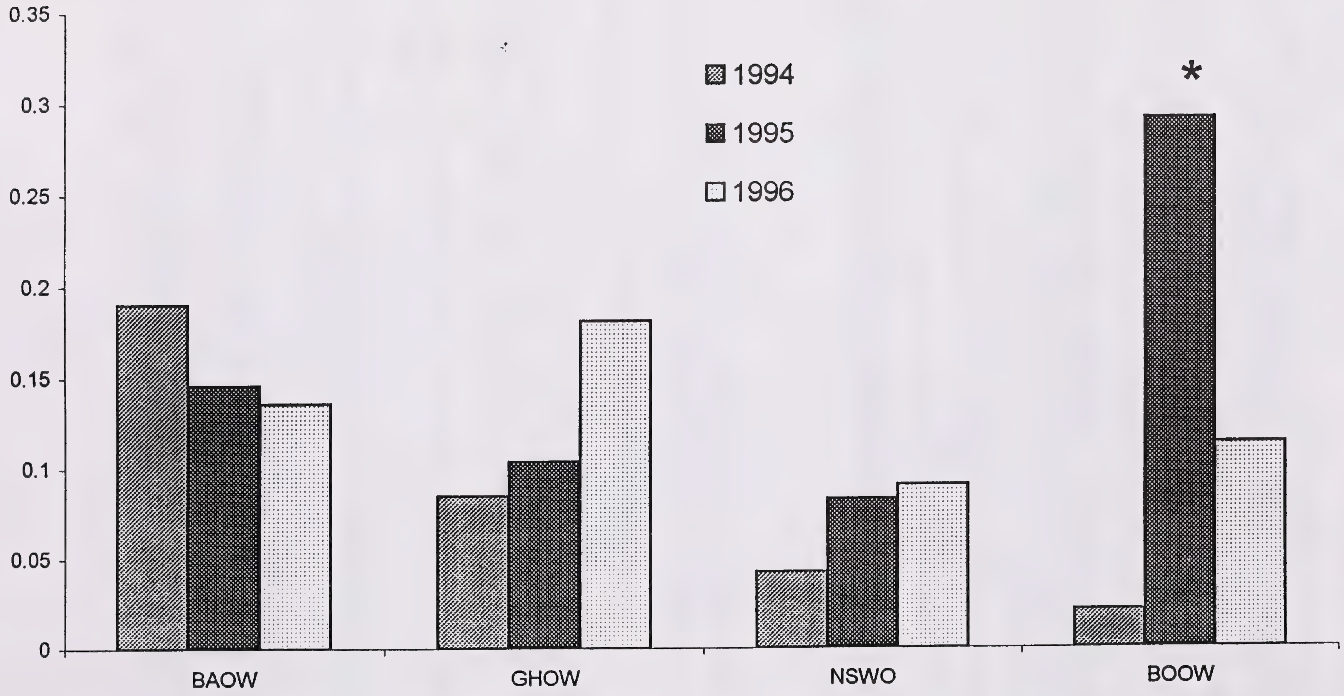

Figure 1. Proportion of responses at 50 playback stations along transects at Calling Lake in each year for four owl species. Pairwise Z-tests were performed to compare response frequency between years. Boreal owl density was considerably higher in 1995 than in 1994 and 1996 ($Z = 3.629$, $Z = 2.12$, $p = 0.05$ respectively). Response frequency for NSWO, GHOW and BAOW did not differ between years.

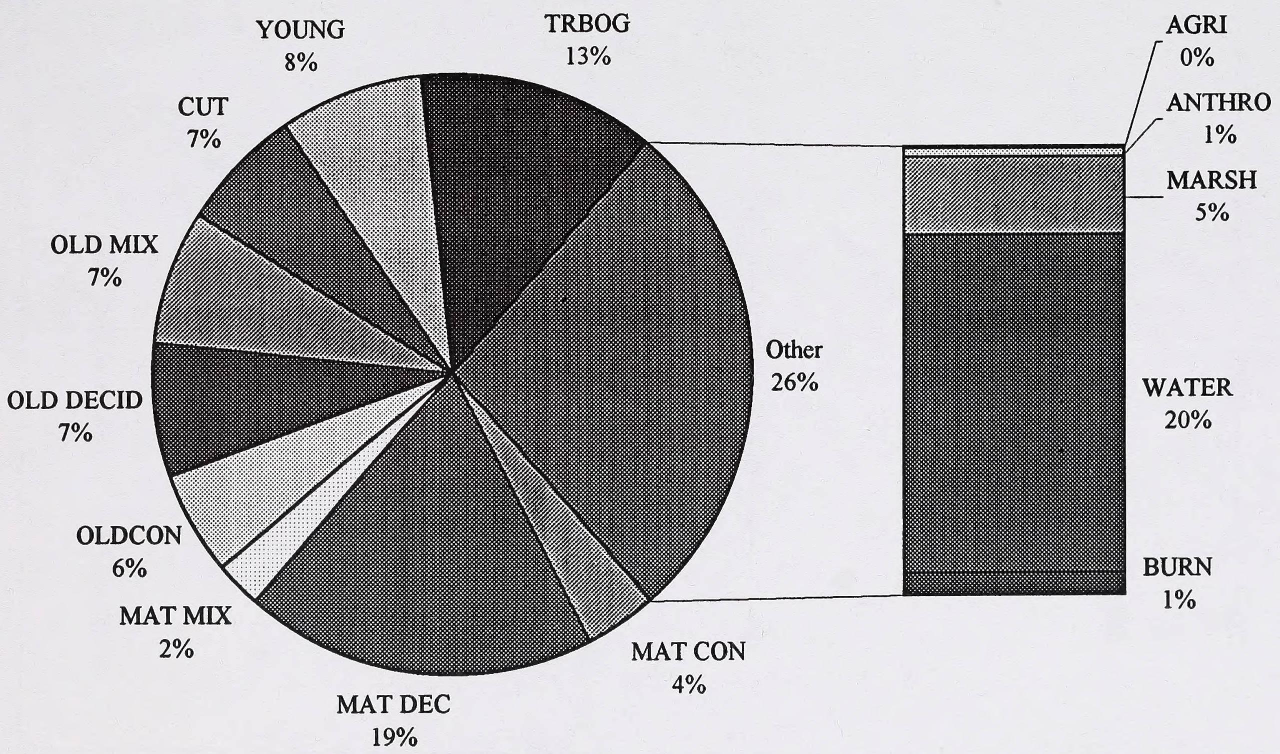

Figure 2. Landscape compositon of the study area.

Figure 3. Log ratio difference scores for summer MCP home ranges vs the landscape. Positive difference scores suggest preference and negative scores suggest avoidance of a particular habitat type.